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Contents

The Unknown Quantity

CONCLUDING a recent article on the "Storage and Treatment of some Food Materials in the African Tropics",* T. W. Barker said :—

"Some contribution to the betterment [in pasteurising and sterilizing fishmeal to make it acceptable for human consumption] of the fishmeal industry in Angola was made *but it cannot be forgotten that the human element can so easily destroy all the potential good done by machinery.*"

We have a feeling that the author would not confine this statement merely to the fishmeal industry in Angola, for the human element can greatly influence any progress be it social or scientific. Man's doubts and fears, traditions and taboos, throughout the course of history, have hampered the harnessing of new, often great ideas, for his own benefit. There are many artists whose work was not recognised until after their death. In the scientific world the views of Pasteur, Lister, Simpson, Hunter, Darwin and even the explorer Columbus provoked long and passionate discussion before being finally accepted by the majority.

The pest control industry has been, and still is, beset with its fair share of problems created by human idiosyncracies. Often we have had to deal with the activities of the "muck and mystery boys", the "witch hunters" and "food faddists".

A recent and slightly different example of the way in which human nature can raise a barrier to social and scientfic progress occurred in the Lake Chirwa area of Nyasaland where African villagers refused to have their dwellings sprayed by the Federal Ministry of Health anti-malaria spraying team. The consequences of this decision will be realised by a brief consideration of the background to the spraying campaign which began in 1956. By 1959 comparison of blood smears taken from villagers in the pilot test area with blood smears collected from an unsprayed area on the other side of the Lake Chirwa showed that there was a significant drop in the incidence of malaria in the test area. Because of this the Ministry of Health intended to carry on the scheme in the pilot area until malaria was eradicated, after which the scheme was to be extended to other parts of the country.

Suddenly in October this year the villagers, who had previously welcomed the spraying team every year since the inauguration of the campaign, refused to have anything to do with them.

Continued on page 56

* Agricultural and Veterinary Chemicals, September/October 1960 pp. 141-145.

KNAPSACK SPRAYERS FOR DISINFESTING SHIP'S HOLDS

The article indicates that the application of insecticides with motorised knapsack sprayers will be more efficient in the disinfestation of ship's holds than smoke generators and will be reasonably comparable in cost.

By F. R. CANN, D.I.C., M.I.Biol. and D. S. PAPWORTH, M.Sc., F.R.I.C.*

As long as ships remain the principal carriers of foodstuffs from one continent to another the need arises to maintain their holds as free as possible from such pests as the Khapra Beetle (*Trogoderma granarium* Everts), the Rust Red Flour Beetle (*Tribolium castaneum* Herbst.), the Rice Weevil (*Sitophilus oryzae* L.), the Indian Meal Moth (*Plodia interpunctella* Hb), and many other insects associated with cereals and their products, oil seeds, dried fruit, etc. These pests gain entry into ships' holds in cargoes already infested in the exporting country.

A large proportion of the insects present in a cargo obviously leave the ship when the infested commodities are discharged (Plate 1) but an appreciable balance get left behind and crawl or fly from the cargo to seek shelter and food material in the innumerable cracks and crevices which the construction of holds provide (Plate 2). Situations in holds where cargo residues can remain and where insects can secrete themselves have been enumerated by Monro (1951) and include bilge spaces, tank top ceilings, shifting boards and wide-angled deck beams. In such places insects have every opportunity to thrive and multiply for several years in cargo residues. With the introduction of another cargo these residual insects emerge from their shelters and infest what may be a clean commodity. Sometimes the commodity becomes contaminated by the presence of insects to such an extent that the importers claim on the ship owners because of the deterioration in quality of the commodity. Examples from the experience of the Ministry of Agriculture, Fisheries and Food are the contamination of cargoes of tea and flour by insects originating in residues from previous cargoes of infested grain and oil seeds.

Because of the danger that clean grain can acquire infestation in this way, certain countries, particularly Canada, require holds to be inspected and officially treated when necessary before cargoes are loaded. For all these reasons the maintenance of insect free cargo spaces is of vital concern to the ship owners and to this end the Infestation Control Inspectors of the Ministry and of the Department of Agriculture and Fisheries for Scotland have, for a number years, been systematically inspecting the cargoes and holds of ships during discharge in the United Kingdom, and have recommended cleaning and chemical control of infestation where necessary.

Where residual infestation is heavy, fumigation of the empty holds with methyl bromide or hydrogen cyanide is recommended preceded by thorough cleaning and removal of cargo residues. Such treatment can only be done by qualified commercial firms and involves the sealing of holds. When hydrogen cyanide is used, the HCN (Fumigation of Ships) Regulations require the ship to be evacuated for the duration of the treatment which may last for up to 24 hours or even longer. Complete evacuation is not always essential when methyl bromide is used, and for this reason and its excellent penetrating powers the popularity of this gas has increased during recent years.

Although fumigation of a ship's hold with gases such as hydrogen cyanide and methyl bromide has been recommended for some years for dealing with insects remaining in holds after discharge of cargoes, such

* Infestation Control Laboratory, Ministry of Agriculture, Fisheries and Food, Surbiton, Surrey.

fumigations are sometimes expensive and difficult to arrange within a limited turn-round period. The use of insecticidal smoke generators and of liquid insecticides which can be sprayed directly on to the walls of a hold are possible alternatives to fumigation.

Advantages of smoke generators

The use of smoke generators has been the more attractive proposition for ship owners for a very long time. Advantages that can be claimed for this method are that no expensive equipment is required. The generators may be bought by the ship owners direct and used under the supervision of ship's officers and treatment can be carried out conveniently either at sea under favourable conditions or at any particular port when cargo conditions permit. The only essential requirement for obtaining some useful control from the use of smoke generators is that the hold be thoroughly cleaned out (ledges swept clean of cargo residues, etc.) before it is closed down and the generators ignited. The use of smoke generators without cleaning is likely to be largely ineffectual for any worthwhile control of insect pests.

Until recently, the two residual insecticides mainly used for the control of storage pests have been *gamma* BHC and DDT. These latter chemicals may be formulated in smoke generators as they are sufficiently stable to withstand heating for the short period whilst the generators are operating, so that most of the active chemical is liberated with the smoke cloud.

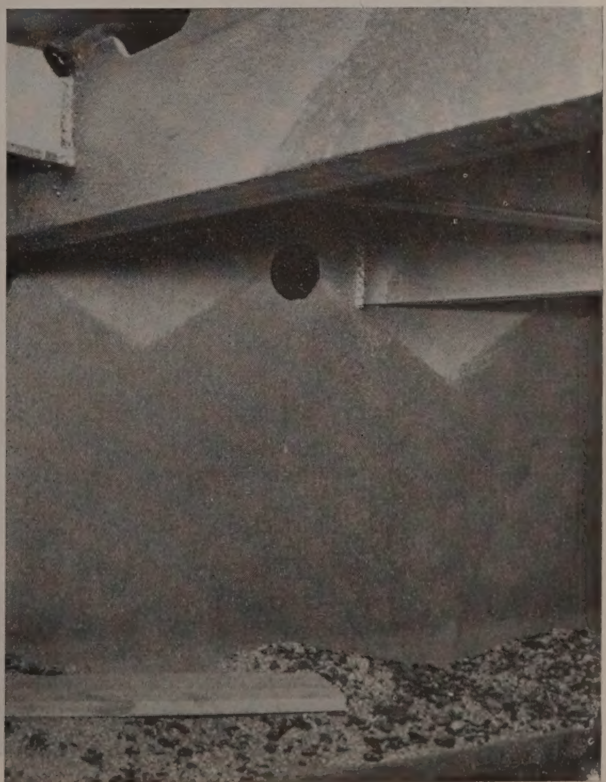
In recent years, however, malathion has largely displaced gamma BHC or DDT for the control of certain common important grain pests, the main examples being Khapra beetle larvae, flour beetles and saw-toothed grain beetles (*Oryzaephilus surinamensis* L.). Because of its relative instability under heat conditions, malathion may not be formulated in smoke generators at a sufficiently high dose for use in the stored products field. Applied as a spray, however, it is far more stable and effective than *gamma*-BHC and its toxicity to certain insects is greater than *gamma*-BHC or DDT.

For these reasons the spraying of ships' holds is now being recommended, particularly as malathion is a most effective chemical for ensuring a lethal deposit in the holds of ships against many common stored products pests.

Although insecticidal sprays have long been used for treating infested stowages in warehouses, they have not been used extensively in ships' holds largely because of the practical difficulties involved in spraying such places as the undersides of the tween decks and the upper parts of bulkheads. With many kinds of spraying machines, ladders or scaffolding would be needed to reach such

Below: Beetles on the deck. Tribolium Castaneum leaving an infested cargo during unloading (Plate 1)

Right: Residues of grain and other commodities on a ledge in a ship's hold (Plate 2)



places. This has often meant that for considerations such as speed of turn-round and expense, spraying was not a reasonable proposition.

Officers of this Ministry have recently carried out tests on several power-operated knapsack sprayers designed for agricultural use, including trials of the machines in ships' holds (Plate 3). These knapsack sprayers are operated by light two-stroke petrol engines and enable spraying up to heights of at least 25 ft. to be efficiently carried out. They weigh not more than 70 lb. fully loaded, cost between £55 to £75, and hold approximately two gallons of insecticide. They have been found mechanically reliable provided careful cleaning and maintenance follows each spraying operation. The average size hold needs between five and seven gallons of liquid. The insecticide can be applied in about 30 minutes spraying time, but as much again may be necessary for lowering the machine into the hold and supplying the necessary water and insecticide. A two man team is necessary to operate each machine. One man will carry the machine, while the other can mix insecticide, guide the sprayer over obstacles and time the operation to ensure even spraying. Operators are advised for their own comfort and protection to wear efficient masks and eye goggles since the air in a hold quickly becomes thick

A motorised knapsack sprayer in use in a ship's hold (Plate 3)

with falling insecticide particles. As soon as the treatment is completed, the hold is ready for loading, which it is not when smoke generators are employed.

In view of a suggestion that the use of the petrol driven machine might produce a harmful atmosphere checks have been made on the concentration of carbon monoxide in holds by means of a pallado-sulphite carbon monoxide detector. In all cases (even when only a few hatch covers have been removed) the concentration by volume of 0.003% carbon monoxide has not been exceeded. The D.S.I.R. leaflet No. 7 "Methods for the detection of toxic gases in industry" states that at a concentration volume of 0.004% carbon monoxide, no ill effects would be sustained by an individual worker doing a moderate degree of physical work. It is apparent, therefore, that there is little hazard involved when using motorised knapsack sprayers in ships' holds. Nevertheless a carbon monoxide detector should be available as a reference check if a very confined space is to be sprayed.

In the process of carrying out the trials referred to above it was interesting to compare the effective deposits of insecticides obtained on vertical surfaces by smoke generators and spraying respectively. For this type of test numbered filter papers 6″ x 6″ were mounted on fibreboard in the vertical plane against suitable supports (e.g. stringers) at different levels of a hold or tween deck. After smoke had had two or three hours to settle or spraying had been completed, the papers were carefully removed into stoppered glass tubes and subsequently submitted to chemical analysis.

Combined DDT/*gamma*-BHC or *gamma*-BHC smoke generators were burnt in two different holds of the same ship. The first hold had a total volume of 61,500 cubic

TABLE I

Deposits of DDT and gamma BHC on vertical surfaces from smoke generators No. 2 Hold (BHC/DDT Generators)

Paper	Location and Height from Deck Level		Deposit in mgm./sq.ft.	
			DDT	BHC
1	Forward bulkhead	8ft.	2	1
2	Port stringer	13ft.	10	1
3	,, ,,	3ft.	14	1
4	Underside of hatchboard	15ft.	3	0
5	Deck surface (Average of 4)		63	3

No. 4 Hold (BHC Generators)

Paper	Location and Height from Deck Level		Deposit in mgm./sq.ft.
6	Forward bulkhead	8ft.	1
7	Starboard stringer	13ft.	2
8	,, ,,	3ft.	1
9	Underside of hatchboard	15ft.	1
10	Deck surface (average of 4)		6

feet and the second 72,600 cubic feet. The number of generators required for the long-term treatment of crawling insects advised by the manufacturers for the cubic capacity to be treated were used. The results of the paper analysis is shown in Table I.

Spraying procedure

The spraying of a hold with malathion took place in one of normal construction with wooden stringers and a mixed steel and wooden ceiling. The hold was twenty-one feet deep from tween deck to ceiling, and this coupled with the fore-and-aft and beam dimensions gave the following surface areas available for spraying :—

Forward bulkhead	200 sq. ft.
Aft	720 ,, ,,
Hold sides	2 x 1200 ,, ,,
Underside of Tween deck (Less hatch square)	500 ,, ,,
Total	3820 ,, ,,

Four gallons of a mixture containing 10 ounces of 30% malathion water dispersible powder were applied to the hold surfaces requiring two fills of the power operated sprayer. It took between five and six minutes to empty the container, and each operation was timed to ensure even distribution of the insecticide for one side and a forward or aft bulkhead. The complete spraying operation was carried out in just under half an hour, and comparable periods were found necessary for other similar holds.

Papers exposed at various points throughout the hold were taken for malathion analysis and the results are shown in Table II.

It will be seen that the average deposits at the various levels are in each case equal to, or in excess of, 75 mg/sq. ft. They are also fairly close to the theoretical applied deposit of 89 mg/sq. ft. A detailed review of the literature together with the extensive practical experience of many workers has led this Ministry to advise the following dosages for use against stored products pests in this country :

gamma-BHC	20-40 mg/sq. ft.
DDT	100 ,, ,,
malathion	75 ,, ,,

When these figures are borne in mind it will be seen that the power-operated sprayer (or spraying equipment of similar efficiency) gives a more effective deposit within the desired range for the control of crawling insects, whereas on vertical surfaces using smoke generators nothing like the same order of deposit for a given chemical is obtained. Once the capital equipment for spraying, in the form of a power sprayer, has been acquired the running costs of applying insecticidal deposits of proved efficacy in the holds of ships (following the discharge of infestable commodities) are now reasonably comparable with those of smoke treatment and the results are markedly superior.

TABLE II

Deposits of malathion on vertical surfaces

Position in hold		Height	Deposit (Mgm/sq.ft.)	
Forward	Starboard	4 ft.	57	
Middle	,,	4 ft.	71	
Aft	,,	4 ft.	81	
Forward	Port	4 ft.	106	Average 128
Middle	,,	4 ft.	183	
Aft	,,	4 ft.	53	
Aft Bulkhead		4 ft.	72	
Forward ,,		4 ft.	401	
Forward	Starboard	10 ft.	12	
Middle	,,	10 ft.	71	
Aft	,,	10 ft.	19	
Forward	Port	10 ft.	49	Average 76.00
Middle	,,	10 ft.	109	
Aft	,,	10 ft.	196	
Forward	Starboard	20 ft.	61	
Middle	,,	20 ft.	105	
Aft	,,	20 ft.	56	Average 75.2
Forward	Port	20 ft.	42	
Middle	,,	20 ft.	112	
Aft	,,	20 ft.	lost paper	
On shelf laid flat to catch fall out		12 ft.	81	
do.	do.	12 ft.	338	

ACKNOWLEDGEMENTS

We are grateful to British India Steam Navigation Co. Ltd., Elder Dempster Lines Ltd., Ellerman's Wilson Line Ltd., and F. C. Strick & Co. Ltd., for providing facilities for carrying out the ships' spraying trials and allowing us demonstration sites on some of their ships. The Liverpool Steamship Owners' Association and the Chamber of Shipping of the United Kingdom are thanked for assistance in organising ship spraying demonstrations.

Much of the field work and public demonstrations were organised by Messrs. T. McDonald, E. G. Hill, M. M. Senior and J. M. G. Gradidge, whilst the analytical work reported was carried out by members of our Liverpool laboratory.

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Anopheles stephensi eggs and larvae. Lateral floats on the eggs and larvae parallel to the surface are Anopheline characteristics

Photo W.H.O.

ANOPHELINE MOSQUITOES AND MALARIA

By B. R. LAURENCE*

In 1947 the World Health Organization[1] estimated that some 300 million persons were affected by malaria each year and that three million of them died. By 1956 Dr. P. F. Russell[2] concluded that about one third of the human population exposed to infection by malaria was protected, notably in Europe, the Americas and the Near East, but that merely about 4% of the population of certain countries received protection. In parts of the tropics some 60% of the children die before attaining the age of 18 months, malaria being the chief contributory factor to this high death rate in the very young.

Mosquitoes and malaria

Malaria is transmitted from one human being to another by Anopheline mosquitoes and, unlike some other human diseases carried by insects, such as yellow fever, plague and some forms of filariasis, human malaria is a disease that affects human beings only and there is, in nature, no known animal reservoir of the disease. There has been a recent suggestion that malaria in monkeys may be transmissible to man, as laboratory workers have apparently contracted the disease from monkeys[3], and malarial parasites have been interchanged in the laboratory between man and the chimpanzee. It is not known if this ever happens in nature. Four types of malaria are found in man and these are the causative organisms of malignant tertian, benign tertian and quartan fever. As these names suggest, the periodicity of the relapses from fever and the severity of the attack depends upon the species of malarial parasite.

Malaria caused by quite different species of parasite is found in monkeys, rodents and birds and Anopheline or Culicine mosquitoes are responsible for their transmission. These species of malaria can be maintained in the laboratory and today they are used a great deal in studies on the life cycle of the parasites and for tests of anti-malarial drugs.

Human malaria is transmitted only by female Anopheline mosquitoes, which require blood meals for the development of the ovaries. These mosquitoes in some parts of the world also transmit filarial worms from man to man. Anopheline mosquitoes are readily distinguished from Culicines by the long palps alongside the proboscis of the female Anopheline, and in the male Anopheline the palps end with a distinct thickening or club. Anopheline mosquitoes often have spotted wings, but this is also sometimes shown by certain species of Culicine.

As is well known, the early stages of mosquitoes are found in the water and the breeding places may be rivers, lakes, ponds, puddles or collections of water in tins, tree holes and the bottoms of canoes. The early stages of Anopheline mosquitoes are distinctive; the eggs are provided with lateral floats and can be found floating on the surface of the water; the larvae that hatch from these eggs rest in the water with the body parallel to the surface. The eggs of Culicine mosquitoes are not provided with lateral floats and Culicine larvae usually hang down from the surface of the water with the body almost vertical.

Infection of Anophelines and transmission

When the mosquito takes an infected blood meal the reproductive stages of the parasite pass, with the blood, to the stomach. After fusion the parasite penetrates the

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stomach wall to form, on the outer surface, cyst-like bodies called oocysts. The oocysts eventually burst to release their contents (sporozoites) into the abdomen. The sporozoites then migrate through the mosquito and aggregate in the salivary glands. At this stage the mosquito is capable of infecting its next human host. The development of the parasite in the mosquito may take from 9 to 12 days at 26° to 27°C.

The readiness with which mosquitoes are infected with malaria and become capable of transmitting the disease to man, varies with the species. It is important in planning control measures to determine which species of Anopheline mosquitoes in a given area are capable of transmitting malaria. To see if an Anopheline is infected, the salivary glands and stomach are dissected out and examined for the presence of the sporozoites and oocysts.

Some species of *Anopheles* feed in preference on man, whereas other species may feed after infection only on other animals and consequently not transmit the disease to another human host. This difference in feeding preferences gives rise to two concepts of the epidemiology of the disease[4]. When malaria is being transmitted by species of *Anopheles* which feed mainly on other animals and consequently bite man relatively infrequently, human malaria is not maintained, unless relatively large numbers of mosquitoes are present. This gives a condition where malaria in the human population is unstable, transmission depending on the number of mosquitoes. If the number falls below a critical density, then despite the continued presence of the vector, transmission may cease, due to the infrequency of contact between infected mosquito and man.

However, in an extremely good season for mosquito breeding large numbers of mosquitoes are produced and thus more mosquitoes bite man and become infected. When this coincides with conditions favourable for the survival of the mosquito, and consequently favourable for the development of the parasite to the infective stage, transmission from man to man will increase, possibly giving rise to an epidemic of malaria.

On the other hand, if the species of *Anopheles* transmitting malaria bite man frequently, possibly in preference to other animals, then transmission from man to man will be maintained, although only relatively small numbers of the vector mosquito may be present. Under these conditions, as in Africa, malaria in the human population will be more stable.

It is possible to find out what kind of host animal a particular mosquito feeds on by collecting the blood from the stomach of engorged females on filter paper, and testing the blood later in saline against antisera obtained from rabbits immunised against known hosts[5]. A recent study by the World Health Organization of the blood meals of vectors of malaria, collected in this way from various parts of the world[6], has shown that a number of important vectors, such as *A. hyrcanus sinensis*, *A. stephensi* and *A. fluviatilis* from India and *A. albimanus* from America take less than 10% of their blood meals from man, whereas *A. funestus* and *A. gambiae* from Africa and *A. sundaicus* and *A. leucosphyrus* from the Far East take 75% or more of their blood meals from the human population.

The difference in feeding habits sets two problems of control. With malarial vectors that feed infrequently on man, malarial transmission will cease if the control measures reduce, and maintain, the mosquito population below a critical density. If, however, the particular vector obtains most of its meals from man then, whilst the vector species is present, malaria transmission may be expected to continue, so long as conditions are favourable for the mosquito to survive and for the parasite to develop to the infective stage.

Control programmes

In many malarious countries the World Health Organization has sponsored campaigns to reduce the incidence of malaria and in some places to eradicate the disease. Because the malaria parasite of man has no alternative animal host it is possible that it can be eliminated from the human population by mass drug therapy associated with the reduction or elimination of the vector mosquito. In India, where the National Malaria Control Programme was inaugurated in 1953 to protect 200 million inhabitants out of an estimated 360 million living in malarious areas, it was decided in 1958 to alter the campaign for the reduction of malaria to one of eradication[7].

One of the principal ways of attacking the disease is by reducing the numbers of the vector mosquito. This in turn reduces the number of contacts between mosquito and man, either of which may be infected and may infect the other. The vector can be attacked in two ways. An attempt can be made to control the mosquito at the breeding places by altering the larval environment—by changes in the vegetation and water—or by spraying with insecticide against the larvae and adults. Secondly, the mosquito can be controlled when it comes to bite man at night indoors, by spraying the walls of houses and associated buildings with residual insecticides.

The first type of control programme, directed against the breeding places, was used before the advent of DDT and the other residual insecticides, but today the main part of a malaria control programme, during the "attack phase", is based on the routine spraying of all human dwellings and animal sheds, which are usually, if only for a short time, the resting places of the vector species at the source of infection. During the attack phase of the present anti-malarial campaign in India

the aim is to spray every dwelling and cattle shed with residual insecticide twice yearly between 1958 and 1961[7]. In Brazil the use of DDT applied in this way to houses had reduced the number of human cases of malaria from 6 million in 1940 to 250,000 by 1958[8]. Similar successes have been reported from many other parts of the world.

Once the incidence of malaria has been reduced the campaign enters what has been called the "consolidation phase" and spraying may be discontinued if the parasite rate is considered low enough and fresh malarial cases are no longer reported. After this the areas under control have to be watched carefully for any evidence of the recurrence of the disease. The estimated cost of the eradication campaign in India between 1958 and 1966 is about 5 annas per head of the population per year—or less than a single treatment for infection with malaria[7].

Although the use of residual insecticides such as DDT has produced spectacular results in the control of malaria, there are some problems which are not completely solved in this way. Obstacles to the universal use of the house spraying methods of control are that some races do not live in permanent dwellings, or they live in huts and houses that have walls that detoxify the insecticide quickly, or even do not have walls to spray at all. At certain periods of the year it is more comfortable in the tropics to sleep out-of-doors and consequently at these times a vector species of mosquito coming to bite man need not come into contact with the insecticide residues on the walls of the dwellings.

An alternative method of control is by mass drug therapy to eliminate the parasite from the human population in malarious areas. This is being tested in parts of Brazil where the human population is scattered and partially nomadic. Here the drug chloroquine is being distributed in table salt, a commodity in demand and used by most of the human inhabitants. The drug is tasteless provided iodine has not also been added to the salt[8].

Another human problem is that persons infected with malaria may move into an area where the disease has either been eradicated or reduced to a negligible level. This has happened after wars when soldiers have returned from malarious countries to Europe, North America and Japan. In these countries malaria has tended to disappear without the impact of present day control measures and the reintroduction of malaria has been followed by epidemics of the disease. The problem of human migration from malarious to non-malarious countries is not only the aftermath of wars. The pacification of islands in the Pacific resulted in greater contact between islands which were previously isolated and the introduction of malaria into islands where it was not known before. The Muslim migrations to Mecca from all parts of the world raise problems of control[9] and so also do the increased facilities in modern times for rapid transportation from one part of the world to another. Not only human beings with unsuspected infections, but also unwanted vectors can be carried about the world in this way. In 1930 *Anopheles gambiae*, a notorious vector of malaria in Africa, was found for the first time in Brazil and was almost certainly introduced from West Africa by aeroplane or fast boat. The spread of this species in Brazil is well documented and in 1938 *A. gambiae*, a "foreign" species, was the cause of one of the worst epidemics of malaria in the Americas. This species was not eradicated from America until 1940, although further specimens, apparently freshly imported, were found three years later. Aircraft nowadays are regularly treated with insecticide and, as an indication of the ease by which mosquitoes travel by air, 32 species of mosquito have been carried to Hawaii in the Pacific by aircraft from other parts of the world.

Insecticide resistance

There are other problems in control programmes concerned with the behaviour of the vector mosquito following the treatment of an area with insecticide. One of the best known of these is the development of insecticide resistance. This appears when mosquitoes carrying genes for resistance to insecticide are selected out of the total mosquito population by the insecticides used, and then continue to breed together until a new resistant population is built up. A recent survey[10] has reported 31 species and varieties of *Anopheles* as resistant, or partially resistant, to one or both of the insecticides DDT and dieldrin, both commonly used in mosquito eradication campaigns. Resistance in a population of mosquitoes has been defined as present when half the sample of mosquitoes tested survive exposure for one hour to 4% DDT or 1.6% dieldrin under the conditions of the W.H.O. standard adult susceptibility test. Resistance to dieldrin appears to be linked to resistance to BHC and if a mosquito is resistant to one of these insecticides it is also resistant to the other.

The genetical origin of resistance has been worked out for a number of species. In *Anopheles gambiae* from West Africa resistance to dieldrin has been shown to be due to a dominant gene so that both mosquitoes that are homozygous, containing two genes for resistance, and mosquitoes that are heterozygous, containing only one gene, are resistant to the action of the insecticide. Resistance is known to become established rapidly in populations of mosquitoes after treatment of an area with dieldrin and, with a dominant gene, half or more of the progeny of a resistant mosquito can be expected to be resistant. Resistance to DDT in *Anopheles*

sundaicus, on the other hand, has been shown to be due to a recessive gene and this may account for the longer length of time that it takes for a mosquito population to build up resistance against this insecticide[11]. Only the mosquitoes homozygous for this gene are able to survive exposure to insecticides and the heterozygotes, containing only one gene for resistance, are susceptible and are killed.

Resistance to insecticides in mosquitoes usually appears following treatment of human habitations with residual insecticides during anti-malarial campaigns, but in some countries resistance, for instance dieldrin resistance in *Anopheles pharoensis* in Egypt, has appeared before such a campaign. Possibly resistance in these species has occured through the use of insecticides in other control programmes, such as those against agricultural pests. The treatment of the larval breeding places may bring the total mosquito population into contact with the insecticide, whereas only part of the population may come into contact with the insecticide residues in houses; thus the different control measures used may variously affect the rate of development of resistance in a vector. Once resistance to one insecticide has been established, some alternative insecticide has to be used. The trend has been towards the replacement of DDT by dieldrin and BHC, followed by the use of organo-phosphorus insecticides. Mixtures of these insecticides and the return to the more extensive use of pyrethrins have recently been considered. A symposium on insecticide resistance has been published in the Indian Journal of Malariology[12] and the World Health Organization have recently issued a report[13].

Effects of insecticide treatment

Besides the physiological or genetical resistance, it has also been suggested that mosquitoes may avoid surfaces sprayed with insecticide and show what is called " behaviouristic resistance ". The evidence for this has recently been reviewed by Dr. Muirhead Thomson[14]. The suggestion implied by the term " behaviouristic resistance " is that the mosquito avoids the treated surface naturally—which may better be called " protective avoidance "—or that irritability to the insecticide is developed after contact with a treated surface, so that the mosquito does not rest long enough for it to absorb a lethal dose of insecticide. Evidence that mosquitoes may avoid insecticide treated surfaces has come from direct observations that they are irritated by DDT deposits and that few or no mosquitoes rest on a treated surface, although numbers may be found on similar surfaces that have not been treated. Field observations have suggested that the numbers of mosquitoes may be maintained in an area treated with insecticide although, when tested, the mosquitoes showed no signs of physiological resistance, and also mosquitoes that have not absorbed lethal doses of insecticide have been captured leaving treated huts.

One of the difficulties of assessing results of this kind is that often only a part of the mosquito population may enter huts and houses and thus come into contact with the insecticide. This proportion of the vector population (endophilous population) will be killed while the outdoor (exophilous) mosquitoes will remain alive. This outdoor population has not developed resistance, either physiological or behaviouristic, but simply has not come into contact with the insecticide. Although the outdoor population may continue to survive, the insecticide treatment breaks malaria transmission by eliminating those mosquitoes that feed at night indoors. If, however, the outdoor population continues to feed largely on man out of doors, as may be the case with *Anopheles gambiae* in Africa, then malaria transmission continues.

One attempt to control malaria in East Africa has produced some interesting results showing the effect of insecticidal treatment of huts and houses on the mosquito population[15]. During the Pare-Taveta Malarial Scheme in Kenya and Tanganyika, *Anopheles funestus*, one of the two most important vectors of malaria in Africa, disappeared from houses, but some mosquitoes, resembling *A. funestus*, were found out of doors having survived the residual spraying. These proved, on examination, to be probably a new species of *Anopheles* which had previously been confused with *A. funestus* but which, because of presumably different feeding habits and not entering houses, survived the malarial campaign. Another finding was that *A. funestus* was not only eliminated but that this species was replaced in the years following spraying by another species, *A. rivulorum*, which became over five times as abundant as before. The increase of one mosquito following the removal of another suggests that the two species were competing with one another, possibly in the breeding places, and that when the competition by *A. funestus* was removed by the treatment of houses with insecticide, *A. rivulorum* then was able to increase in numbers. As *A. rivulorum* feeds on cattle and does not enter houses, this species is not concerned in the transmission of human malaria.

"Races" of *Anopheles* and Malaria Transmission

The discovery of what is apparently a new species, after the elimination by insecticides of the species with which it has been previously confused, shows that, although Anopheline mosquitoes may be very similar to one another, different populations of apparently the same species may have very different habits when alive in the fields, and this may be an important consideration during the control of the transmission of malaria. One

of the best known cases of mosquitoes that resemble one another but which differ in habits and importance as vectors of malaria is that of the *Anopheles maculipennis* complex of species in Europe. It was known that, despite the wide distribution of these mosquitoes in Europe, malaria was localised, being abundant in one locality, yet rare elsewhere. Later work showed that, although the females of this complex were almost identical, they laid very differently patterned eggs. By this one could distinguish females of two species that were very good hosts for the malarial parasite, now referred to as *Anopheles sacharovi*, *A. labranchiae* and its race *atroparvus*, and females of another species that were not good hosts, now referred to as the races of *A. maculipennis*. These different species and races were also shown to have different habits and were incompatible when mated. Similar races, or species, of what has been known as *Anopheles hyrcanus sinensis* have been reported recently in the Far East, one of which lays narrow-decked eggs and is more markedly attracted by man, and consequently is probably more important in the transmission of malaria, and filariasis.

Length of Life of the Vector

The average expectation of life of a mosquito probably varies from one season to another, and malaria transmission may not be possible at some times of the year. In the dry season in parts of the tropics, for example, transmission may cease because either the female mosquitoes are not living long enough for the parasite to develop, or the conditions of humidity and temperature prevent the flight of the females between the breeding places and the villages and towns where they obtain their infections. A recent development has been the possibility of judging the age of female mosquitoes captured in the field by dissection and examination of the internal organs, especially the ovaries. Each time a mosquito lays eggs a small relict swelling is left in each ovary stalk (ovariole) and it is possible to count the number of batches of eggs a mosquito has laid before capture by counting the number of relict swellings[16]. As the minimum length of time between one egg laying and the next is known, the age of the mosquito can be roughly estimated. The ability to distinguish between young and older mosquitoes is useful if large numbers are being dissected to determine the infection rate with malaria in any particular species, for the young females can be discarded as they will be too young to be infected and need not be examined. It may prove that these young mosquitoes can be recognised also on external characters, such as the amount of external wear, without dissection being necessary[17]. Studies of the ageing and survival in female mosquitoes following spraying are useful as these should show if the campaign is successful, a reduction in the length of life of the mosquitoes sufficient to interrupt transmission indicating the success of the control measures. The method of carefully following the mortality of mosquitoes during an insecticide campaign also provides a sensitive method for detecting the early development of insecticide resistance, when the resistant mosquitoes will be expected to survive much longer than the others.

The stable type of malaria found in Africa is the most stubborn to resist control programmes. Recent attempts to control *Anopheles gambiae* in East Africa[15] have shown that an increase of the average daily mortality of the females from 13-15% before spraying to 21-25% afterwards, was not high enough to interrupt the malarial cycle. This result did not, however, mean that the control programme did not reduce the incidence of malaria, but that transmission from man to man was still potentially possible. The outdoor population of *Anopheles gambiae* was reduced by over 90% and *A. funestus*, which rests for longer in houses and huts, had virtually disappeared, yet malaria remained.

In French West Africa[18] the principal vectors in untreated villages were the usual vectors in Africa, *Anopheles gambiae* and *A. funestus*, but in villages treated with DDT these mosquitoes have been replaced in importance by another species, *A. nili*, which appeared to play the part of the principal vector of malaria, and again malaria transmission has not been brought to an end.

In other countries control programmes have proved outstandingly successful—despite the appearance of insecticide resistance—and should the insecticide campaign against the vector mosquito fail to prevent the transmission of the parasite completely, the use of drug therapy to eliminate the parasite from the human host leaves an alternative method of attack.

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PENTACHLOROPHENOL

Its properties as a wood preservative

By J. Sproule*

Pentachlorophenol (PCP) and its derivatives have, during the past twenty-five years, become recognised as being amongst the best-known, and most widely used preservatives for timber, hardboard, fibreboard and chipboard.

In these applications high toxicity to insects and micro-organisms is essential, but PCP and its derivatives owe much of their success in a diversity of uses to their physical and chemical properties. Chemical stability, colour, odour, volatility, solubility and the effect on metals and other materials are all factors which determine the usefulness of chemicals as practical preservatives. It is the purpose of this review of PCP and its derivatives to describe the chemical, physical and biological properties which are the basis of their successful practical use for nearly a quarter of a century.

Manufacture

Pentachlorophenol was first described by Erdmann in 1841, and its practical preparation by the direct chlorination of phenol reported by Merz and Weith in 1872. Although its existence had long been reported in technical literature, it was not until the 1930's that its preservative properties were appreciated, and commercial manufacture started by Monsanto Chemical Company in the United States in 1936.

The most straightforward, and still the most common method of making PCP is by the direct chlorination of phenol. The major impurity in PCP made by straight chlorination is tetrachlorophenol. As this is also a chemical of high micro-biocidal activity, it is neither economic, nor of practical value to aim at 100% yield of PCP.

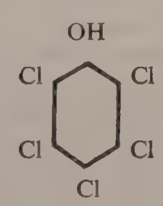
In practice chlorination is stopped when the reaction product has reached a crystallising point of 174/5°C. corresponding to approximately 88/90% PCP. Further chlorination increases the yield of PCP, but also breaks the benzene ring and gives over-chlorinated products which tend to be strongly coloured, and insoluble in the solvents commonly employed with PCP.

* Monsanto Chemicals Limited

An alternative method of making PCP is by the hydrolysis of hexachlorobenzene.

Chemistry of Pentachlorophenol

Pentachlorophenol is phenol which has been chlorinated as far as possible without destruction of the benzene ring. All of the ring hydrogens are thus replaced by chlorine. It has the structural formula:-



Pentachlorophenol is a fairly weak acid with a dissociation constant of the same order as that of acetic acid (about 10^{-5}). As would be expected, the presence of chlorine atoms makes it somewhat more acidic than phenol itself. For an organic compound it is remarkably stable to heat, and does not undergo decomposition even if held at temperatures of up to 300°C. for an extended period of time. It is therefore stable at the temperatures employed during pressure impregnation, or in the manufacture of building boards. It does not split off chlorine to a measurable extent when boiled in aqueous solution, the chlorine atoms being firmly bound to the benzene ring. It does, however, undergo some decomposition by ultra-violet light in aqueous suspensions, with the release of hydrogen chloride.

Although a considerable number of organic derivatives of PCP have been prepared, none has shown greater micro-biocidal activity than the parent compound or its metallic salts. The only organic derivative to find commercial application has been lauryl compound which although slightly less toxic than PCP possesses physical properties which fit it admirably for its major role as a long term preservative for textiles.

Pentachlorophenol is attacked very little by the common oxidising agents, with the exception of fuming nitric acid which converts it to chloranil and chloropicrin.

Pentachlorophenol is readily soluble in caustic alkalis to yield the water soluble sodium and potassium salts which are recovered in the solid state upon evaporation. It does not readily dissolve in aqueous ammonium hydroxide at ordinary temperatures, but will do so at the boiling point, or in the presence of a small proportion of alchohol, to form the sparingly soluble ammonium pentachlorophenate.

The alkali salts are readily converted back to PCP even by weak acids, including atmospheric carbon dioxide, the formation of PCP starting at a pH of 6.8 and reaching completion at a pH of approximately five.

Metallic salts other than those of sodium and potassium are virtually insoluble in water and are prepared by the mixing in aqueous solution of chemically equivalent quantities of sodium pentachlorophenate and a water soluble salt of the metal. As commercial sodium PCP always contains free alkali in the form of caustic soda, this should be neutralised (to a pH of about 8.5) if contamination of insoluble metallic hydroxides is to be avoided. In practice this refinement is rarely necessary.

Over 20 metallic salts of PCP have been prepared and studied, but of these only the sodium, potassium, ammonium, copper, lead and zinc salts have been put to commercial use. Apart from being readily converted back to the free phenol by acids, the metallic salts can, for practical purposes, be considered stable and unreactive. Copper pentachlorophenate shows some decomposition above 150°C. and is, therefore, less stable at elevated temperatures than PCP—there is also evidence that it can be broken down slowly by intense U.V. light.

Analysis of the "aluminium salt" prepared from aluminium sulphate and sodium PCP shows that the precipitate formed consists of a mixture of free PCP and aluminium hydroxide. Aluminium pentrachlorophenate, if formed at all, must be hydrolysed almost immediately.

Whilst the heavy metal salts of pentachlorophenol, notably copper PCP, are used for the preservation of timber, wallboard and fibreboard, it is both cheaper and more practicable to form them *in situ*, than to make them commercially for sale. As a wood preservative, copper PCP is normally required as a solution in an organic solvent, and is most conveniently made by the reaction of copper naphthenate with PCP in a petroleum distillate.

Physical Properties of Pentachlorophenol

Appearance : Technical PCP is a greyish-brown solid naturally produced in flake form. On storage the colour lightens due to slow sublimation which coats the flakes with powdery crystals which have a lower pentatetra ratio than the base material. A 5% solution of PCP in organic solvents has a light wine red colour whose intensity is often unrelated to the depth of colour of the solid material.

Crystallising Point : The pure compound, forms white crystals with a crystallising point of 190.2°C. The technical material normally crystallises at between 174 and 175.5°C.

Solubility in Water : One of the main virtues of PCP as a long term preservative under conditions of exposure to the weather, is its low water solubility, which has been determined as follows : —

TABLE I

Solubility of Pure PCP in Distilled Water

Temperature °C	Solubility ppm	Temperature °C	Solubility ppm
0	5	40	25
10	10	50	35
20	14	60	53
27	18	62	58
30	19	70	85

The technical product has a somewhat higher solubility due to the greater solubility of tetrachlorophenol.

Solubility in Organic Solvents[1]

(a) *Industrial solvents* : Pentachlorophenol is readily soluble in many organic solvents. In the top bracket are the lower alkyl alcohols dissolving from 50-60% at 20°C.

Good solvents which also possess anti-blooming properties are Yarmoor pine oil, di-alkyl phthalates and tri-aryl phosphates with solubilities of between 30 and 40%.

(b) *Commercial Oils* : It is more soluble in highly aromatic oils than in those which are predominantly paraffinic. In petroleum distillates its solubility normally increases with increase in specific gravity and boiling range. It is not possible to give a comprehensive or accurate list of solubilities in petroleum based solvents, as these will depend on the nature of the crude oil from which they are derived.

In general tar oils, e.g. anthracene oil and creosote, and heavy petroleum fuel oils will dissolve upwards of 25% of PCP. Its solubility in the lighter petroleum distillates, e.g. diesel oil, kerosene and white spirit, is usually 5% or less.

Natural and modified natural resins, although they may themselves be solids, often increase the solubility of PCP in relatively poor solvents such as white spirit and light petroleum distillates. A particular case is the amine of dehydroabietic acid, which appears to combine chemically with PCP.

Vapour Pressure : A property of pentachlorophenol which contributes to its permanence as a wood preservative is its low vapour pressure at normal temperatures as shown by the data in Table II.

Technical PCP is somewhat more volatile due to the presence of tetrachlorophenol, whose vapour pressure at 20°C. is 0.14mm of Hg.

TABLE II

Vapour Pressure of Pure Pentachlorophenol

Temp. °C	Mm. Hg.	Temp. °C	Mm. Hg.
0	0.000010	150	2·51
20	0.00011	200	27·37
50	0.0023	250	189·1
100	0.019	300	932·1

Volatility in Steam: In the manufacture of insulating board and hardboard these products initially having a high water content are subsequently pressed and conditioned at temperatures well in excess of 100°C. It is, therefore, important that any preservative incorporated in the board should have a low volatility in steam. For pure PCP the figure is 0.167g per 100g of steam at 100°C. The significance of this low value becomes apparent in the termite proofing of building boards, where losses of technical PCP through volatilisation during pressing and conditioning rarely exceed 2%. It is probable that much of this will be tetrachlorophenol, whose volatility in steam at 100°C. is 1.325g per 100g of steam.

Physical properties of Pentachlorophenates

The most important salt is sodium PCP, widely used for sapstain control, for the termite and rot proofing of chipboard, hardboard and insulating board, and for the *in situ* eradication of dry rot and other fungi in buildings. It is important to remember that whilst the property of sodium PCP which accounts for its widespread use as an alternative to PCP is its solubility in water, it is converted back to the insoluble parent compound under acid conditions, or by absorption of carbon dioxide from the air.

Appearance: In appearance technical sodium PCP is light buff in colour and is sold either as a powder, in pellet form, or as a 15% aqueous solution.

Technical sodium PCP contains a percentage of free alkali varying from between 0.3 to 1% calculated as NaOH which gives a pH of about 10.3 in 1% solution, compared with a pH of 9.0 for pure sodium PCP. The solid forms of technical sodium pentachlorophenate may vary in moisture content from 5 to 13%.

Solubility in Water: Sodium PCP dissolves rather slowly in water and some heating is desirable to speed up the rate of solution. More exact figures are as follows: —

Temperature (°C.)	lbs. sodium PCP per 100 lbs. solution
21	5
25	10
29	20

Solutions are reddish-brown in colour, and tend to darken on exposure to light. Re-solution of crystallized concentrated solutions (i.e. 10% or upwards) can be obtained by heating but may be made somewhat more difficult by the formation of the monohydrate which has a lower solubility than the anhydrous salt.

With hard water, solutions of technical sodium PCP are invariably slightly turbid due to the formation of the insoluble calcium and magnesium salts. As the quantities are small and these salts are also fungicidal, the diminution of effective strength of the solutions is negligible. Some clarification can be achieved by the use of a sequestering agent, such as sodium hexametaphosphate, after first making the dissolving water slightly alkaline with caustic soda.

Solubility in Organic Solvents: The only organic solvents in which sodium PCP will dissolve with any readiness are acetone, and the lower alcohols.

Sodium PCP is appreciably more soluble in mixtures of ethyl alcohol and water than it is in either solvent on its own. Whilst the solubility in water at 0°C. is only about 15% w/w, and in industrial alcohol about 27% w/w at the same temperature, the solubility in a mixture containing 40% industrial alcohol and 60% water is 45.9% w/w or 57.6% w/v. With 20% of industrial alcohol in the solvent, a solution containing 44.7% w/v can be prepared. In practice these solutions are made by dissolving PCP in an aqueous solution of alcohol and sodium hydroxide.

Physical properties of heavy metal salts

Of the metallic salts other than sodium PCP, only those of copper and zinc are used commercially in wood preservation. Copper PCP, a reddish-purple solid is the most widely used of the heavy metal salts and its physical properties have been investigated in some detail.

Vapour Pressure: Details of the vapour pressure of PCP and copper PCP at various temperatures are given below. Up to 100°C. the vapour pressure of the copper salt is about half that of PCP.

Temp °C.	Vapour pressure (mm. of Hg.)	
	Pentachlorophenol	Copper pentachlorophenate
20	0.00011	—
50	0.0023	0.001
75	0.019	0.010
100	0.12	0.067

Solubility in Water: At normal temperatures copper PCP has approximately the same solubility as PCP and at 40°C. has a solubility of 35 ppm.

Solubility in Organic Solvents: Copper PCP is not readily soluble in organic solvents other than carbitols and cellosolves. Only butyl carbitol and butyl and methyl cellosolves are capable of dissolving more than 20% at normal temperatures. These solutions can be diluted to some degree with water without precipitation. Stable solutions in water can be prepared by the addition of sodium PCP to copper sulphate, sequestered with tetrasodium pyrophosphate. On impregnation into timber the wood acids bring about the deposition of copper PCP.

Solutions containing both copper and PCP may also be formed by the addition of PCP in a water miscible

TABLE III

Egg Laying Compulsion Tests (Each cage containing blocks treated with a single preservative)

Preservative	Date Treated	No. of Eggs Laid			No. of larvae tunnelling in		
		1943-4	1944-5	1945-6	1943-4	1944-5	1945-6
Water Soluble A	7.2.45	—	—	381	—	—	357
Water Soluble B	?.4.40	—	—	397	—	—	373
Pentachlorophenol	29.6.44	—	0	0	—	0	0
Orthodichlorobenzene	11.5.43	0	14	285	0	11	263
Controls	24.4.45	301	393	457	285	362	417

organic solvent to cuprammonium solutions. On impregnation into timber, and the evaporation of the solvent, the compound formed is not, however, copper PCP but copper diammonium pentachlorophenate.

In wood preservatives of the organic solvent type, copper PCP is formed by the interaction of PCP and copper naphthenate in a light petroleum distillate. Solution strengths obtainable are higher than those which can be achieved by dissolving copper PCP precipitated from aqueous solution, indicating that naphthenic acids are effective solvents for copper pentachlorophenate.

Toxicity to insects

As is the case with many of the toxic ingredients used in wood preservation, the available scientific data on the effectiveness of PCP against the various wood destroying insects has largely been published outside the U.K. At the present time there is no standard procedure in the U.K. for the evaluation of insecticidal wood preservatives,* and to date the attitude has been that the proof of the pudding is in the eating—or, in this case, the lack of it.

Pentachlorophenol and its salts act in varying degrees against insects as repellents, contact and stomach poisons and as ovacides. When applied by pressure impregnation, hot/cold bath or steeping, the retentions are considerably in excess of the quantities required to prevent attack, and it is mainly when preservatives are applied by brushing or spraying, and particularly in the treatment of timber already infested, that their precise toxicity becomes important.

Common Furniture Beetle (Anobium punctatum) : — The most comprehensive experiments are those which have been carried out in New Zealand by J. M. Kelsey[2] and D. Spiller[3]. For a full appreciation of their work, the original papers should be read in their entirety, but an indication of the effectiveness of PCP can be gained from tables III, IV and V relating to tests carried out by Kelsey on impregnated wood blocks.

The residual contact and ovacidal action of PCP has also been investigated by Spiller[3], who summed up his

* *However, a B.S.I. committee has recently started work on formulating standard tests.*

TABLE IV

Transfer of Anobium Larvae to Treated Blocks

(5 replicates, 30 larvae in each experiment)

Preservative	Total No. of Larvae Alive After Seasoning for (in months)			
	8	16	24	32
Water soluble A	0	—	—	—
Water soluble B	7	—	—	—
Zinc chloride	9	11	7	10
Pentachlorphenol	0	0	—	—
Kerosene	0	0	3	21
Dithiodichloro-benzene	0	4	19	21
Control	27	26	28	27

Each experiment was carried on for 8 months, when further fresh blocks treated at the same time as the first lot set up.

TABLE V

Brush Treatments of Anobium-Infested Timber

Preservative	No. of Coats on vertical surface	Total % of dead larvae after 49 days (Average of 3 tests)
Pentachlorophenol	1	25.79
	2	46.23
	3	77.77
	4	98.31
Chlorinated naphthalene	1	37.85
	2	50.00
	3	92.72
	4	98.63

findings as follows—" It was found that PCP acted as a residual contact insecticide, an average of 0.18 eggs per female being laid on blocks treated with 2.2% PCP compared with 8.2 eggs per female on untreated blocks. Further, of the eggs laid on treated blocks only 23.3% hatched compared with 93.4% hatching on untreated blocks. These two factors gave a control equivalent to killing 99.4% of potential eggs.

Lyctus Beetles : —
Precise data on the effectiveness of PCP in preventing Lyctus attack is meagre, but on the evidence of unpublished work carried out in Australia and in the U.K., it would appear that non-pressure treatments with pentachlorophenol are less effective in preventing attack by *Lyctus*, than in the case of *Anobium*. In South Africa. Krogh and Tooke[4] have given 0.6-0.8 lbs. per cu. ft. with a minimum penetration of ¼" as being the minimum absorption necessary to prevent attack.

The effectiveness of PCP in dealing with this pest in infested timber has been conclusively demonstrated.

P. N. D. Krogh and F. G. C. Tooke[5] reported as follows "a 5% concentration of the chemical PCP was used with encouraging results. Single brush coatings were applied to very heavily Lyctus-infested 3″ boards of limba wood. In all specimens borer activity ceased immediately, and on opening them up no live larvae could be detected. To date two years later, whilst borer activity continues unceasingly in the untreated limba controls, the treated boards show no renewal of activity. By this simple method of application, penetration of between ⅛ and ¾″ were affected in both radial and tangential directions. All galleries up to 2″ below the surface, moreover, were thoroughly permeated".

House Longhorn Beetles (Hylotrupes bajulus) : — The toxicity of PCP against *Hylotrupes bajulus* has been investigated at considerable length in the Union of South Africa by H. J. R. Durr[6]. The effectiveness in preventing attack on timber being demonstrated by the results of the following tests :

1. Effect on Longevity of Females:

Treatment	Longevity (Days)
Control	10.4
Copper Naphthenate	10.1
Pentachlorophenol	6.35
Coal tar distillate	6
Wolman salts	3.9
DDT	3.7
BHC	2.9

2. Effect on Number of Egg Batches Deposited by Females:

Treatment	Average No. Egg Batches Per Female
Control	2.3
Copper Naphthenate	1.7
Pentachlorophenol	1.1
Coal tar distillate	0.7
Wolman salts	0.6
DDT	0.15
BHC	0.04

3. Effect on Viability of Eggs in Contact with Treated Wood:

Treatment	Mean No. of Eggs per Batch	Mean No. Hatched
Pentachlorophenol	25.40	3.50
Wolman salts	33.80	5.47
Copper naphthenate	45.00	10.67
Control	78.00	56.75

The effectiveness of PCP against the larvae of *Hylotrupes* is somewhat anomalous. As can be seen from table VI, there is relatively high mortality rate when the young larvae are placed on the surface of treated timber.

However, in an eleven months' trial in which larvae were inoculated into pre-treated wood, PCP at 0.08 lbs. per cu. ft. (above the level recommended by Tooke for the prevention of attack by *Hylotrupes* and *Lyctus*) failed to bring about 100% mortality. Further tests indicated that a retention of 0.11 lbs. per cu. ft. was desirable.

It was noted by Durr that zinc naphthenate was less effective than PCP against young larvae in contact with treated timber, but was more effective when the larvae were inside. Various combinations of PCP and zinc naphthenate were tested, and it was concluded that 3% zinc naphthenate plus 2% PCP satisfied all the requirements of a preservative against *Hylotrupes*. Whilst there is a temptation to think that this is due to a synergistic action, it is more probable that the superiority of this combination over equivalent quantities of the individual ingredients is due to the formation of zinc PCP.

TABLE VI

Effectiveness of the Contact Action of Insecticides and Preservatives on Young Larvae on the Surface of Treated Timber :

Preservative	Mortality of 36 Larvae After 2 days	Mortality of 36 Larvae After 7 days
Creosote	33.6	36
PCP (in turpentine)	28.4	35.4
DDT	26.3	36
BHC	25.6	36
Wolman salts	8.5	25.5
Copper Naphthenate	1.4	15.4
Control	3.6	16.4

Extensive investigations into the effectiveness of PCP against *Hylotrupes* have also been carried out in Germany. According to Becker[7] the threshold value for PCP against egg-larvae of *Hylotrupes* when tested in accordance with DIN. 52165 lies between 3 - 5 kg/m^3 (1.88 - 3.12 lbs./cu. ft.).

It is apparent that whilst PCP is effective against *Hylotrupes* at all stages of its life cycle, there is a danger with surface treatment of obtaining a retention insufficient to give lasting protection against attack. It is therefore recommended that where the possibility of attack by *Hylotrupes* exists, or in the treatment of timber infested with these insects, that PCP-based preservatives are fortified by the addition of one of the more powerful insecticides. In the U.K. it has become common practice to add dieldrin at a concentration of 0.5%.

Death Watch Beetle (Xestobium rufovillosum) : — Death watch beetles are not insects which lend themselves to laboratory test methods, and it is not therefore surprising that there is no data of a truly scientific nature on the effectiveness of PCP against this insect. Fortunately, however, PCP and its salts have a long history of successful use in the eradication of death watch in infested timber.

Termites : — To restore the balance there is a wealth of information on the effectiveness of PCP and its salts against a variety of species of termites. Detailed studies have been made in Australia of the effectiveness of various preservatives preventing attack on timber and hardboard. F. J. Gay and A. H. Wetherly[9] have concluded that the minimum concentrations required to prevent significant attack on a susceptible timber by

the termite *Nasutitermes exitiousus* are :

Pentachlorophenol	0.54%
Trichlorophenol	1.33%
Dichloronaphthalene	1 - 2%
Tetrachloronaphthalene	1%
Pentachloronaphthalene	0.5%

Hardboards made from fibres of susceptible species were found to be made highly resistant to termite attack by the incorporation of 0.75% of PCP[9].

In the eradication of termites in infested timber, J. M. Kelsey[2] has shown that 21 days after treatment a single brush coating of 5% PCP effected an 85% kill of *Calotermes brouni* in 6″ x 1″ timbers when only the top surface was treated. Two brush coats increased the percentage kill to 90%, and three coats brought it up to 100%.

In the field PCP has confirmed its value as a long term preservative against termites in the International Termite Exposure Test[10] stake tests[12] and post studies[11] carried out by the Forest Products Laboratory, Madison, in termite infested areas in the U.S. and central America.

Toxicity to wood destroying fungi

Whereas there are gaps in our knowledge of the precise toxicity of PCP towards wood destroying insects, there is a vast amount of published information on its toxicity towards fungi. Of fundamental importance is its effectiveness relative to other chemicals used in wood preservation, and this is demonstrated in table VII : —

The toxicity of all the major wood preservatives to the common wood-destroying fungi has been determined by E. B. Cowling[14] using the soil block method, the threshold values for PCP being as follows : —

	Test Fungi	Threshold PCP in Pounds per Cubic Foot
I.	*Fomes subroseus*	0.24
	Poly. tulipferae	0.11
II.	*Poria incrassata*	0.075
	Poria monticola B	0.061
	Poly adustus	0.061
	Poria monticola A	0.053
	Poly. versicolor	0.048
	Poly. hirsutus	0.043
III.	*Lenzites trabea A*	0.039
	Lentinus lepideus	0.030
	Poly. abietinus	0.030
	Poria vaillantii	0.030
	Poria xantha	0.025
	Lenzites trabea B	0.022
	Daedalea quereina	0.022
	Lenz. saepiaria	0.011
	Schiz. commune	0.011
	Ster. frustulosum	0.011

For comparison the toxic limits as determined by the standard British and German methods are given in Tables VIII and IX.

TABLE VII

Toxicity of Various Chemicals to the Fungus *Fomes annosus* When Tested by the Agar-Petri-Dish Method[13]

Chemical	Killing Concentration (% By WT)
Arsenic Trioxide	0.025 (I)
Borax	0.13
Boric Acid	0.25
Copper Arsenate	0.04-0.05
Copper Sulfate	0.064 (I)
Ferric Sulfate	CA 0.2
Sodium Arsenite	0.044 (I)
Sodium Chromate	0.034
Sodium Dichromate	0.03
Sodium Fluoride	0.25
Zinc Meta-Arsenite	0.10
alpha Chloronaphthalene	0.006
Coal Tar Creosote	0.05-0.35
o-Phenylphenol	0.01-0.02
Pentachlorophenol	0.002
Sodium Pentachlorophenate	0.002
Sodium Tetrachlorophenate	0.002
Tetrachlorophenol	0.002

Toxicity of Pentachlorophenates to fungi

All metallic salts of PCP are toxic to fungi, and the majority, including sodium PCP, differ little from PCP in respect to their inhibiting and killing concentrations. The notable exception being copper PCP which is significantly more toxic than its parent compound, as shown by figures in Table X obtained by the petri dish method .

The indication that copper PCP is approximately twice as effective as PCP in preventing decay has been borne out by field trials[17, 18].

The field trials [10, 11, 12] previously referred to in connection with termites also indicate the long term effectiveness of PCP against wood-rotting fungi.

Toxicity to plants

PCP and its derivatives are toxic to plant life and are not recommended for use on greenhouse timbers or seed boxes. The latter restriction does not apply in the case of mushroom trays, where a dip treatment with sodium PCP has shown to be extremely beneficial in preventing the growth of unwanted fungi without harming the crop.

Toxicity to humans and animals

With few exceptions, all wood preservatives are, in varying degrees, toxic to humans and animals. Whilst PCP treated timber is perfectly safe to handle after the evaporation of the solvent, direct contact with both the solids and their solutions should be avoided, by the wearing of appropriate protective clothing, and the prompt washing off of any solid material or solution coming in contact with the skin.

TABLE VIII

Approximate toxic Limits of Pentachlorophenol to Wood-Destroying Fungi[15]

Fungus	Species of Timber	Method of Exposure	Approximate Toxic Limits: As Strength of Treating Solution %	KG/M3	As Absorption of Pentachlorophenol Lb. Per. Cu. Ft.
Chaetomium globosum	Beech	Abrams' Mycelial mat method	1-2	6-12.5	0.37-0.78
Polystictus versicolor	Beech	BS.S. 838	0.25-0.3	1.12-1.22	0.07-0.076
Coniophora cerebella	Scots Pine Sapwood	B.S.S. 838	0.15-0.25	0.6-1.13	0.038-0.071
Lentinus lepideus	Scots pine Sapwood	B.S.S. 838	Below 0.0375	Below 0.16	Below 0.01
Poria vaporaria	Scots pine Sapwood	B.S.S. 838	0.15-0.25	0.6-1.13	0.038-0.071

TABLE IX

Thresholds of Fungicidal Effectiveness of Pentachlorophenol Determined by Din. 52176. Blatt I.

Fungus	Species of Timber	Thresholds in kg preservative per m3: Standard Strain	All tested strain
Coniophora cerebella	Scots Pine Sapwood	1 - 1.5	0.7 - 5
Poria vaporaria		2 - 33	0.3 - 4
Merulius lacrigmans		0.7 - 1	0.7 - 1.5
Lentinus lepideus		0.3 - 0.4	0.15 - 0.4

TABLE X

Comparison of the Toxicities of Copper Pentachlorophenate and Pentachlorophenol to Fungi[16]

Organism	Concentration of of Copper PCP: inhibiting	Killing	Concentration of PCP: Inhibiting	Killing
Lentinus lepideus	0.0005%	0.001%	0.002%	0.004%
Lenzites sepiaria	0.0005%	0.001%	0.002%	0.006%

Extensive tests with farm animals[19 20] have proved that PCP treated timber is safe for use in farm buildings, and is incapable, of giving rise to the so-called X disease in cattle.

Summary

Pentachlorophenol and its derivatives are established wood preservatives of considerable versatility. They can be applied by any of the recognised methods of treatment, and with few exceptions are suitable for preservation of timber, plywood, and manufactured building boards under all conditions of exposure.

They are also used for the protection of logs and unseasoned timber for fungus infection, and form a component of many of the formulations used for the *in situ* treatment of woodworm and dry rot in buildings.

This versatility makes it all the more important that their properties, virtues and limitations be clearly understood, as however effective a preservative is, it cannot give the performance expected of it if wrongly or inadequately formulated or applied.

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Promoting the Study of Pests of Standing Crops

MANY WILL be aware that this year's meeting of the British Association for the Advancement of Science was greatly concerned with the problem of providing food for the underfed millions. (It is estimated by some authorities that ⅔ of the world population, if not starving to death, are inadequately fed.) In relation to this theme one of the subjects discussed was "Pests of Standing Crops" which contained three papers dealing with pest control In the main all three papers indicated the importance of studying the ecology, life history, behaviour etc. of pests. The importance of utilizing natural predators and parasites for the control of pests was emphasised in all papers but, as will be seen from the following abstracts, studies of biological control and population dynamics are still in the early stages and pesticides despite their disadvantages are still the most reliable method of controlling pests.

Control of Cabbage Root Fly
by D. W. Wright

After a brief description of the life cycle, habits and importance in relation to the severe damage that can be caused to brassicae crops, of the cabbage root fly, the author gave a description of experiments to determine the importance of natural controlling factors in checking rapid increases in cabbage root fly populations. From these experiments, carried out at the National Vegetable Research Station, Wellesbourne it was apparent that the most efficient natural controlling agent is a complex of carabid ground beetles of which *Bembidion lampros* was the most important. These beetles are especially active in warm sunny weather and will eat over 90% of all the root fly eggs laid before they can hatch. Cold weather decreases the activity of the beetles and hence their efficiency. Moreover heavy rain can seal the cracks in the soil where the root fly eggs are laid, consequently protecting them from the beetles. Thus showery weather at the time of egg laying leads to severe crop damage.

To show the effect of beetle predators on the cabbage root fly population a series of experiments were carried out during April, May and June when the attack by the first generation of root fly occurs and when the wingless form of *Bembidion lampros* was the most important predator, having moved to the field from overwintering sites in the hedge rows. Certain plots were surrounded by a shallow straw filled trench, which had been treated with insecticide. On these plots the number of beetles in the plot were reduced. Other plots were surrounded with one way catch barriers which allowed beetles to enter but not to leave. Consequently the number of beetles in these plots were increased. On other plots insecticide was applied according to the standard method for the control of cabbage root fly i.e. localised soil treatment around the base of the stem. Untreated control plots were also included. The results of the experiment are shown in figures 1, 2 and 3 and in table 1.

It can be seen that carabid predators greatly reduce the number of cabbage root fly larvae and the crop damage. Unfortunately the reduction in cabbage root fly numbers by predation is insufficient to prevent considerable economic crop loss with the more valuable brassicae crops so that chemical control of the remaining population is necessary.

The use of high concentrations of insecticide applied locally around the base of the plant (i.e. standard treatment) gives control of the pest and does not seriously affect the predator population. However, general distribution of insecticide through the upper layers of the soil can greatly reduce the number of predators. This situation may arise where insecticides are broadcast and worked into the soil or, with the highly persistant chemicals, where insecticides occur as residues from the treatment of previous crops. In either case the local concentration of insecticides is liable to be too low to affect the root fly eggs or larvae, but sufficient to be toxic to the more mobile predators.

Consequently agriculturalists may well find that crops such as kale, swedes and cabbage, which in previous years had not suffered serious root fly damage, may be seriously affected by this insect when grown

TABLE I.

Yield and grade size of cauliflowers (75 plants per plot) Wellesbourne 1959

Treatment	*Mean weight of Marketable heads in Kg.*	*Mean Numbers of 1st grade heads over 5 ins. diam.*
Untreated	27·9	12·0
Dieldrin plant treatment	50·2	31·0
Catch-barrier	28·6	13·7
Strawbarrier DDT	17·4	7·3

on land carrying residues of insecticides. Obviously then when combating a known pest problem which requires treatment with a highly residual soil insecticides the management of succeeding crops should be planned to avoid this difficulty.

Current Research on the Control of Fruit Pests

by Dr. G. H. L. Dicker and R. C. Muir (East Malling Res. Stn.)

Pest control may be approached in three ways, (a) by making the physical environment hostile to the pest by applying chemicals toxic to them (b) by encouraging natural enemies of the pest so checking its increase and (c) by breeding plants unacceptable to the pest in question.

The authors illustrated these three approaches by using as an example the apple crop which, because it is a costly adventure, requires the control of those insects and mites known to cause economic injury.

Regarding the use of chemicals a typical present day spray programme includes.

The use of DDT, BHC or an organophosphorous compound in April for the control of aphids, apple capsid and various caterpillars. The apple sawfly, can be controlled, when the larvae hatches just after the blossom period by BHC to which it is susceptible. Several chemicals are used against the fruit tree spider and the codling moth caterpillar. In addition, from early April until early July fungicides are applied at ten to fourteen day intervals to protect foliage and fruit against fungal scab and mildew.

Complete sterilization of an orchard, however, is neither practical nor desirable and as apple trees are insect pollinated spraying operations must cease during the blossom period.

Successful pest control by chemicals is dependant mainly on a sound knowledge of the biology of the pest species, effective chemicals and efficient application. The main factors determining the most appropriate time to apply chemical control measures are firstly, the spray must be applied at a point in the life cycle of the pest when it is susceptible and secondly before any serious injury has been caused to the host plant. Only by detailed knowledge of the habits of species can these points be decided and nowadays lack of biological information is

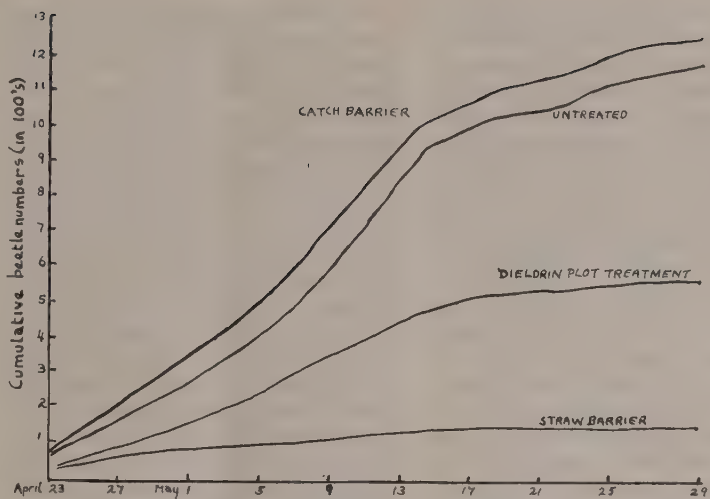


Fig. 1. Effect of different barriers on the number of beetles in cauliflower plots (Wellesbourne 1959)

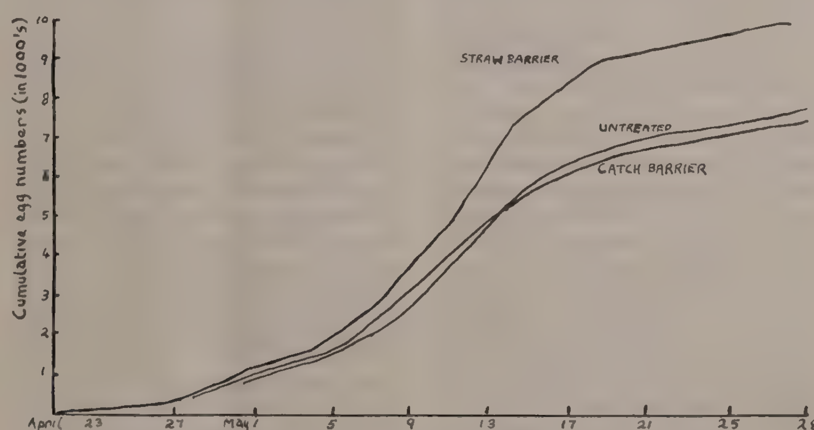


Fig. 2. Number of cabbage root fly eggs on cauliflower plants surrounded by different barriers (Wellesbourne 1959)

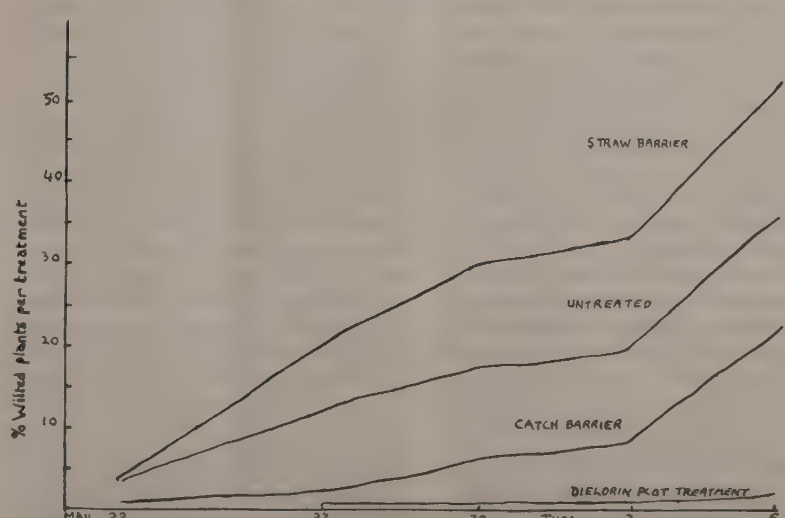


Fig. 3. Effect of different barriers on the number of wilted cauliflower plants

often a greater hinderance than the availability of chemicals. Moreover each pest species must be considered individually. For example the apple blossom weevil comes out of hibernation in March when practically the entire overwintering population is present on trees before egg laying begins and the application of a contract insecticide at this time will result in complete extermination. The codling moth on the other hand, emerges from underneath the bark, where it overwinters in the caterpillar stage, at the end of May and continues to do so for two months. Throughout this period eggs are being laid and the young larvae, on hatching, quickly tunnel into the fruits where they are safely hidden from the effects of most chemicals. For success a continuous toxic deposit has to be maintained through this period and studies are still in progress to discover the most effective chemical and necessary frequency of application to achieve this.

Lead arsenate can be applied at petal fall in mid May and at the end of June to catch the early hatching larvae and again in mid July to catch the later ones. However because of its human toxicity further applications of lead arsenate are inadmissable. The contact insecticides, DDT, Sevin and Gusathion can be used for later applications because of their lower mammalion toxicity, in addition they are more effective insecticides. An unfortunate corollary to this increased efficiency is that, unlike lead arsenate, they also kill the parasites of the fruit tree red spider mite which consequently increases in numbers and is raised to a pest status. Thus in eliminating the codling problem we create a *mite* problem. At present this is no great obstacle as there are sufficient specific acaricides to deal with this pest but it must be remembered that the red spider is particularly proficient at producing resistant strains.

In unsprayed orchards this mite is controlled by a succession of hemipteran parasites. These, however are susceptible to many chemicals normally used for pest and disease control with the result that few survive in the sprayed orchard. Therefore the present problem is to devise a spray programme which will give satisfactory control of the other pests and diseases and yet not destroy the natural enemies of the mite.

One field experiment along these lines was started in 1953 and continued to 1959, using four simple spraying shedules. These were winter wash DNOC applied early in March, versus no winter wash. Superimposed on this was a fortnightly application of fungicide—lime sulphur or captan —from early April until the second week in June. Blanket sprays of nicotine were used against sawfly, and lead arsenate against codling, neither of these sprays being considered toxic to the predators.

For comparison those plots receiving applications of winter wash and lime sulphur were considered as treated, as lime sulphur is toxic to the larvae of the mite predators (it is also slightly toxic to the mite) and those plots receiving captan alone were held to be the untreated or control plots as captan has no effect on the hemipteran parasites.

The effects of the treatment were that in 1954 more mites were found on the untreated plots due to the absence of the controlling influence of winter wash, lime sulphur and mite predators. In 1955 the position at the outset was the same as in the previous year, but by the end of July the untreated plot had fewer mites, a difference which increased as the season progressed. In 1956 the position opened as in previous years, the untreated control carrying more mites, increasing until July when both populations collapsed and dropped to negligible numbers by the end of the season. In 1957 the mite populations after a poor start recovered faster on the treated plots than on the control. This was continued through 1958. In 1959 the populations were checked again.

Part of the explanation for this result can be attributed to the incidence of the Black-Kneed capsid (*Blepharidopterus angulatus* Fall) which appeared to be the main mite predator. It was observed, with the exception of 1959, that the predator was more abundant on the untreated plots. There was a steady increase in numbers of the predator from 1954 to 1956 when it was sufficiently abundant to bring about the collapse of the mite population in that year. The mite population was reduced so drastically that the predator was left with little to eat, and the population was reduced. This reduction in predator population which was even greater on the treated plots due to the additional effect of the treatments allowed the mite population to increase and continue through the next year reaching the highest peak on the treated plots. The gradual increase in food supplies allowed the predator population to increase on the treated plots until sufficient survived in 1959 to bring about a check in the mite population. On the untreated control plot the predator population remained constant through 1957, 1958 and 1959 and was always adequate to maintain control of the mite.

Unfortunately this success does not solve the commercial problem because mildew is serious on the captan plots. The search is now for an alternative fungicide which will control mildew but not adversely influence the predator population.

The third approach to pest control, that of breeding for host resistance is essentially a long term approach to the problem, for example the apple root stocks resistant to wooly aphid attack took 30 years to develop. Other drawbacks include the fact that resistant strain of plant may not be resistant to all strains of a pest species.

Population Dynamics of Some Native and introduced Forest Insects in the Atlantic Provinces of Canada.

By R. F. Morris Forest Biology Laboratory, Fredricton N.B. Canada

In introducing this paper the author stated that the Atlantic Provinces of Canada, namely New Brunswick, Nova Scotia and Prince Edward Island, provide some unusual opportunities to study the natural population behaviour of forest insects. The forest is important to the economy of this area and a considerable effort is expended both in extensive surveys of annual insect abundance and in intensive population research on certain species. Relatively undisturbed forest stands are often available and areas as large as 20 to 30 square miles have been reserved from cutting and spraying for the study of natural populations. Also the three Provinces are separated by bodies of water which are not wide enough to prevent transmigration of species but which are wide enough to separate populations; thus we can learn whether oscillations are in phase in separate populations that are subject to the same air mass climatology. Finally, because of the

sea ports, this is often the first area in N. America to receive invasion of foreign species and we have had several good opportunities to study the behaviour of such pests before and after the introduction of biological control agents from the country of origin.

To those interested in population dynamics, biological control and ecology this area is a dream world and Mr. Morris made full use of these advantageous conditions by producing a most interesting and informative paper. However, because of the recent nature of some of these studies definate conclusions can only be made after a few more years of study.

The author used a number of graphs of the population trends of various species to show the interaction between both native and introduced pests, their parasites or predators and hosts. Typical oscillations of a native insect can be seen in Fig. 1, which shows the population trend for the Fall webworm. It is interesting to note that the mean population density in Nova Scotia (N.S.) is higher than that of New Brunswick (N.B.). The reason for this is at present unknown. It can also be seen that the webworm cycles are in phase in the two provinces and in fact they are in phase throughout a large part of eastern and central Canada. The dotted parasite line for the New Brunswick population before 1920 results from a study of natural control carried out by Dr. J. D. Tothill. Similar parasite lines for both populations over the last five years are from the author's studies which show that the same sequence of parasites effective 40 years ago are still effective today.

The population trends of introduced species are more erratic as one would expect from the unstable equilibrium that their introduction creates. The two examples we have chosen from the paper are the European Spruce Sawfly Fig. 2 and the balsam wooly aphid, Fig. 3. With the European Spruce sawfly the initial outburst following the introduction caused damage to the spruce crop as shown by a depression in the food supply line. Parasites were introduced from the countries of origin but a virus disease (V), apparently introduced along with the parasites, spread very rapidly and was the initial factor in reducing the high sawfly population. Introduced parasites (P) then became effective. Continued extensive population studies show that the sawfly and its parasites are now oscillating at a low level and are behaving like a typical native species. The spruce population has returned to its original level.

The balsam Woolly Aphid is a different proposition for it has no parasites. Introductions of predators are being continued from Europe and Asia but as yet have not been successful. The result is that where this insect occurs balsam fir trees have been reduced in numbers to a few scattered survivors. The sudden drops (W) are the result of severe winter temperature which kills most of the aphids above snow level. However, the aphid quickly recovers.

Mr. Morris tentatively concluded that the great majority of native forest insects in the Atlantic Provinces oscillate about discrete mean (or equilibrium) densities and these oscillations, which seldom rise to the limit of the foliage supply, appear to be largely the result of host-parasite interaction. The fact that oscillations are in phase in separated populations appears to be a result of a common air-mass experience, and this is receiving more detailed study. Mean densities vary from forest to forest, or from province to province, presumably as a result of forest types and climatic regimes. It may prove profitable in the continued research that is planned on these species to consider the mechanism of oscillation and the mechanism of mean density determination as separate but related problems. A very few native species, such as the spruce budworm, are exceptions to the general rule that they sometimes escape the regulating mechanism and erupt to the limit of their food supply.

On the other hand introduced species, if they become established at all, appear to increase very rapidly to the limit of their food supply. This applies both to the defoliators that are introduced accidentally *and to the parasites and predators that are purposefully introduced to control them.* If the primary food supply is readily exhausted, like the foliage of evergreen trees, great loss of wood may result as has been shown for the spruce sawfly. If the primary food supply is more readily replenished, like the foliage of larch or oak, the loss of wood may be delayed considerably or even indefinitely. The introduction of natural enemies can change this situation very drastically, as the spruce sawfly study has shown and the larch casebearer study has suggested, but the biological control work on other introduced species is too recent to permit definite conclusions.

There are conflicting theries about population dynamics but the behaviour of native and introduced forest insects in the Atlantic Provinces appears to offer greatest support to ideas expressed by Dr. A. J. Nicholson on the role of intra-specific competition. Alternative theories on population dynamics have been advanced by other workers. However the contrast in population behaviour between native and introduced forest insects in the Atlantic Provinces, and between introduced species before and after the introduction of their natural enemies, does not lend support to those theories which propose that either weather or intrinsic genetic mechanisms can limit an established population below the level at which intra-specific competition occurs. These things, however, along with ecological factors that vary from stand to stand in the forest, are probably of great importance in determining the absolute population density at which intra-specific competition becomes effective, as well as the mean density about which oscillations occur.

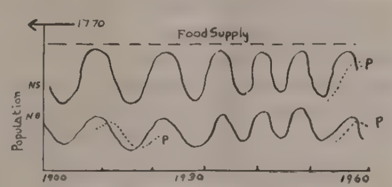


Fig. 4. Fall Webworm (Native)

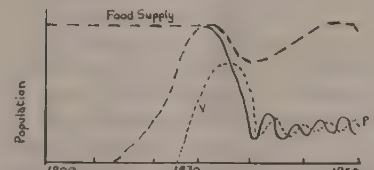


Fig. 5. European Spruce Sawfly (Introduced)

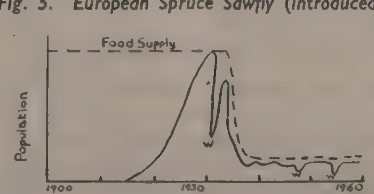


Fig. 6. Balsam Woolly Aphid (Introduced)

NEWS AND NOTES

Phytosanitary regulations relaxed for the export of nursery Stock to Canada

The Canadian Department of Agriculture has, subject to stringent conditions, acceded to requests that certain nursery plants should be permitted to enter Canada with soil on their roots. The concession is restricted to plants such as azalea and rhododendron that cannot safely be exported following the removal of soil. All other plants must be shipped substantially free from soil, sand or earth, and there is no other change in Canadian certification requirements.

The conditions of the concession are:-

Exporters must enter into a *written agreement* with the Ministry of Agriculture, Fisheries and Food, undertaking to comply with the following rules:-

(a) The nursery or premises shall have been thoroughly soil-sampled by Officers of the Ministry and neither potato root eelworm nor potato wart disease shall be known to occur on any part of it.

(b) Potato tubers or plants and tomato plants shall not have been grown on the exporting nursery or or premises or allowed to come into contact with the soil there *for at least three years* prior to the movement of plants with soil to Canada.

(c) No sand, soil, earth, compost or green vegetable manure shall be introduced into the exporting nursery or premises, unless it has originated from premises which conform with conditions (a) and (b) above.

(d) Bags, crates, baskets, hampers or other containers which have previously been used to harvest, store or move any plant, raw vegetable or other material originating on land where potato root eelworm or wart disease occurs shall not be used to harvest, store or move any plant or parts of plants offered for export to Canada.

(e) Ploughs, cultivators, diggers, hoes, spades, barrows, carts, wagons, trucks or other impliments or vehicles which have come in contact with soil or products or the soil originating in nurseries, greenhouses, or other premises where potato root eelworm or wart disease occurs shall not be used for the cultivation, harvesting, storage or movement of plants being offered for export to Canada without first having been thoroughly cleansed of all adhering sand, soil, earth or vegetable matter.

(f) When plant parts which have been bought in or moved from other premises, are offered for export to Canada with soil, the nursery or premises of origin shall have entered into a similar written agreement with the Ministry.

(g) The Nursery or premises shall be open to Official inspection at all times. The above conditions apply to all plants or parts of plants offered for export to Canada with soil, whether grown on the exporting nursery, planted there temporarily, heeled in, or otherwise brought into contact with the soil there.

Exporters wishing to enter into a written agreement for exporting nursery stock to Canada should write to the Ministry of Agriculture, Fisheries and Food, Plant Health Branch, London, S.W.1.

Spot weeding

Fisons' new 'Ridweed' spot weeder performs a new service for the gardener and groundsman. Ridweed (2,4,5-T/2,4-D mixture) packed in one of The Metal Box Company's tinplate aerosols, is specially designed to eliminate individual or isolated patches of weed on the lawn or bowling green, without dousing nearby plants.

Spot weeding is achieved by means of a Precision Valve which is specially made to be used only with the jet pointing downwards. It is operated by pressing on the white polythene applicator. The spray is concentrated in the area occupied by the weeds, which can be as small as 2ins. in diameter. The surface design is executed by Metal Box in full colour, by offset lithography. The aerosol is untreated internally.

Hazards of aerial application !

Once upon a time a Tiger Moth pilot was spraying potato fields in Somerset. Flying over a neighbouring farm he heard two bangs and on landing found holes in the wing of his aeroplane. Undetered he reloaded and returned to the field to continue with his work. Lo and behold when he passed over the neighbouring farm for the second time he heard more bangs and looking down he saw a man in a field. Now perhaps this man in the field had a grudge against aeroplanes or then again being a farmer and not an entomologist he may have mistaken the Tiger Moth for the codling moth which had been attacking his fruit trees, but whatever the case he aimed his gun at the poor defenceless aeroplane and fired two more shots.

Some time later the man in the field was taken to task by the magistrate who duly punished him for his wicked deed.

Why did he shoot at the aeroplane? "Well," he said "I don't like crop spraying from the air. Aeroplane noises can cut the milk yield of my cows and the spray may drift over the grass and give it a bitter taste".

New Cyanamid International Scientific Co-Ordinator for Europe

Dr. Walter F. Jepson, has been appointed by Cyanamid International as a regional Scientific Coordinator for agricultural chemicals in Europe.

In his new post Dr. Jepson will be based at Cyanamid of Great Britain Limited, Bush House, London, but will travel throughout Europe to give on the spot scientific and technical advice to agriculturalists on the control of plant pests and diseases. Prior to his appointment Dr. Jepson was Reader in Tropical Applied Entomology at the Imperial College of Science.

Mr. Hesse described the appointment of Dr. Jepson, whose career includes extensive experience in Europe and Africa, as a further step in the company's programme to provide technical support in the field for Cyanamid's wide range of agricultural chemicals and products.

At Bush House Dr. Jepson will be a colleague to Dr. W. M. McKay, who has been regional Scientific Coordinator in Europe for animal feed and health products. Subjects of particular scientific interest to Dr. Jepson include stem-boring insects of grain crops and sugar cane, and the protection of food in granaries.

Research study group on toxic chemicals used in agriculture and food storage

The Minister of Agriculture, Fisheries and Food, together with the Minister of Science, the Secretary of State for Scotland and the Minister of Health have appointed Professor R.E. Lane, C.B.E., M.B., B.S., M.D., F.R.C.P., M.R.C.P. and Mr. T. A. Oxley, B.Sc., A.R.C.S. to succeed Dr. Hunter and Dr. Galley who have had to resign from the Group.

Professor Lane is Nuffield Professor of Occupational Health at Manchester University and Mr. Oxley is an Assistant Director (Advisory) of the Tropical Products Institute.

Dr. Hunter has resigned his position on the Study Group owing to pressure of his medical duties. Dr. Galley has resigned on taking up an appointment with the Shell Group as research director and manager of the Woodstock Agricultural Research Centre.

Ministry to pay for destruction of trees infected with fire blight in private gardens

Owners of trees infected with fire blight in private gardens will in future have the choice of either destroying the trees themselves or having them destroyed by the Ministry of Agriculture; in the latter case, the Ministry will bear the whole cost. This is the effect of an amendment to the Fire Blight Disease Order, 1958, made by the Minister of Agriculture, Fisheries and Food.

Fire blight is the most destructive disease of pear and apple trees known. The 1958 Order was made when its presence was confirmed in pear orchards in Kent and Worcestershire; and the strenuous efforts made under those powers to wipe out the disease in those orchards have been very successful.

A new problem emerged when the disease, which can spread rapidly, was found in private gardens particularly in the Southend district. Various ornamental shrubs, such as pyracantha, cotoneaster, whitebeam, mountain ash and hawthorn were infected.

The Ministry can expect to learn of outbreaks of the disease on farms and publicly owned land from special surveys by its inspectors or through reports from owners. With private gardens, however, the readiness of owners to report suspected outbreaks is an important link in the campaign to eradicate the disease. Some private owners may have been reluctant to report the disease for fear of the expense to which they might be put in destroying infected trees. They will now know that, if asked to do so, the Ministry will destroy such trees without cost to them.

Much has already been achieved with the co-operation of commercial growers, local authorities and many private householders. It is hoped that under these new arrangements, all private householders will co-operate so that the existence of the disease becomes known speedily and this source of infection is stamped out.

These new arrangements are experimental. No effort must be spared to eradicate this new disease before it becomes established or spreads to other parts of the country. The position will of course have to be reviewed in the light of experience; but it is hoped that all the measures now being taken will lead to the complete eradication of the disease.

European Weed Research Council

The International Research Group on Weed Control met in Lincoln College, Oxford, on the 5th and 6th April, 1960. This Group was formed at Ghent in 1958 and held its first full meeting at Stuttgart in 1959. The purpose of the meeting at Oxford was to consider the future of the Group as well as to discuss certain specific weed problems.

The report of the meeting has only recently been issued and states that the meeting agreed that co-operation between European weed research workers was mutually desirable, but that a minimum of central organsiation was necessary. In this respect, the idea of founding a European Weed Research Society was rejected, but the creation of a European Weed Research Council was approved. The Council was elected with officers Professor B. Rademacher (Germany) President, Dr. R. Longchamp (France) Vice President, Dr. W. van der Zweep (The Netherlands) Secretary-Treasurer, J. D. Fryer (England) Editor. The Council is completed by one member from each of the interested European countries. The headquarters of the new Council will be at Wageningen in the Netherlands. The countries so far participating are: Austria, Belgium, Denmark, Finland, France, Federal German Republic, German Democratic Republic, Gt. Britain, Italy, Ireland, the Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey.

The Interim Council of the International Research Group recommended to the meeting two ways in which co-operation between workers could be fostered. The first method was the formation of small working groups on specific aspects of weed control; and the second the foundation of a new journal devoted to the publication of studies on weeds and their control. Such a publication would gather together papers hitherto widely separated in the literature and consequently often unavailable.

The newly formed European Weed Research Council met during the Conference and decided that it would support groups of specialists in the formation of Committees which are established to study specific and well defined problems. It will be necessary for the incipient committees to prove both enthusiasm and need for a particular study before Council will sanction the affiliation. Council announced that the following committees are officially affiliated — the Committee for *Avena fatua* (and related species), the Committee for *Pteridium aquilinum* and the Committee for the study of experimental methods.

The new journal will be named "The Journal of Weed Research" and Mr. J. D. Fryer (England) will be the Editor, with Professor B. Rademacher (Germany) and Dr. R. Longchamp (France) as Assistant Editors. The general policy of the Journal will be the responsibility of the Editors, but papers submitted for publication must be of the highest standard. Papers will be accepted if written in English, French or German, provided an adequate summary is presented in the other two languages. The first issue of the Journal is scheduled to appear in January 1961. Financial support for the Journal rests with the European Weed Research Council who are seeking financial guarantors throughout Europe. Several Industrial Companies have already agreed to act in this capacity, as have a number of non-commercial organisations.

NEWS AND NOTES

More Pyrethrum for Japan

Japan is manufacturing more insecticides and this is expected to result in greater imports of pyrethrum from Kenya, the world's main source of supply.

The increase in production of insecticides is to meet the growing requirements in Japan, traditionally a pyrethrum producer, of public health authorities and also the growing demand in the Far East and South East Asia. Japanese manufacturers are, of course, well placed to take advantage of openings in the South East Asia market.

There is a particular demand in Japan and nearby countries for mosquito coils. These are spiral coils of combustible material containing pyrethrum, which is lighted and slowly burn killing or repelling mosquitoes and other flying insects. The manufacture and export of these coils is also increasing.

Japan before World War II was the world' main source of supply of pyrethrum. Dr. E. A. Baum, a technical representative of the African Pyrethrum Technical Information Centre, on returning to Kenya after an extensive tour in the Far East, has reported that whereas Japan produced 12,800 tons of dried pyrethrum flowers in 1935, it produced only 2,500 tons last year. There was little indication that Japan would return to its pre-war pyrethrum production level. This pointed to an increasing market in Japan for African pyrethrum, whether as dried flowers or extract.

Some Want Jam on it!

Many methods have been used to attract pests to poisoned bait or traps, for example we have heard of the use of damp sausage, bread mash, soaked wheat and oatmeal in poison baits for the control of rats, a peanut butter/kepone poison bait has been used for the control of fire ants, sugar/organophosphorous insecticide mixtures have been used as poison baits for the control of flies, ultra violet light has been used to attract moths and other positively phototropic night flying insects to traps and the scent of a female sawfly has been tested in an attempt to attract male sawflies to a poisoned trap. However, one of the most recent attractants used in a poison bait is even more unusual. The attractant is none other than apple and raspberry jam which, mixed with 1080 (Sodium fluoroacetamide), is used as a poison bait for the control of oppossums in the 24,000 acre Rotoehu State Forest, Rotorua, New Zealand. Mind you, ordinary jam is not enough for this pest it has to be dyed green.

However, this unusual method of controlling the oppossum is not so ridiculous as it may appear. The oppossum was introduced into New Zealand in 1870 and having no natural enemies it multiplied alarmingly. It is now serious pest in many parts of New Zealand causing direct damage to trees and indirectly accelerating damage to land from erosion and flooding. The combination of jam and green dye arouses the curiosity of the opposum but apparently the dye deters birds from sampling the poison bait. Results from an assault in which "men armed with 'jam guns' have spread two-ounce blobs of the toxic bait over 100 acres of the floor of exotic stands" have been very promising.

Bracken Control

After several years of trials in Scotland, Ireland, the north of England and elsewhere Mirvale Chemical Company's new product — to be sold under the trade name Teridox in Britain and Frondox overseas — is proving successful for the eradication of bracken.

The material which effects the whole plant, is applied at maximum foliage growth when it is translocated throughout the plant. An application of $1\frac{1}{4}$ gallons per acre is claimed to achieve an 80% kill of bracken and the few fronds emerging in the year following treatment can be spot treated. The best results are obtained by applying the chemical when the fronds have just reached full development usually mid-July in southern England, August in the north and mid-August in Scotland.

Cost for sufficient material to treat one acre of bracken is estimated to be in the region of £4/15/0 and it is hoped to obtain, eventually, a Government Grant for chemical eradication along the lines of the existing cutting grant.

As the Mirvale Chemical Co. Ltd. do not sell to retailers, arrangements are being made by their agents, Messrs. Joseph Weil & Sons, London, to appoint distributing companies throughout England, Wales and N. Ireland. The sole Scottish distributor will be Messrs. H. M. Roemmele & Co. Ltd., Glasgow.

Birfield Group change headquarters address

From Monday, November 7th, the headquarters of the Birfield Group of Companies will be located at their new London offices at 20, Hill Street, London, W.1. The telegraphic address becomes *Beltistos, Audley, London*, but the telephone number is unchanged at *Grosvenor 7090*.

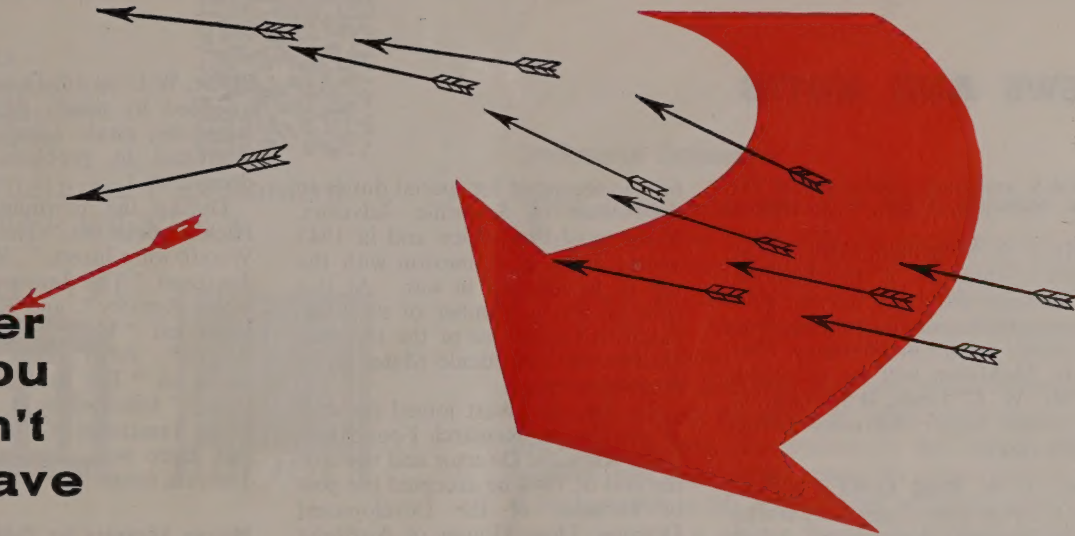
Royal Show site

The Royal Agricultural Society of England have announced that negotiations are in progress for leasing from Lord Leigh a site for a permanent base for the Royal Show at Stoneleigh Abbey, near Kenilworth, Warwickshire. The lease will cover an initial period of seven years, with an option for a long lease in the event that both the site and the arrangement proves acceptable. The negotiations are subject to planning permission being obtained from the relevant local authorities, and also subject to contract.

The Site, which comprises about 500 acres, lies between the A.444 and the B.4115 roads, approximately 5 miles due south of Coventry, and is about 10 miles to the east of the M.1. It is expected that it will be ready for the first Show to be held there in 1963, following the 1961 Show at Cambridge, and the 1962 Show at Newcastle upon Tyne.

The decision follows the instructions of the Society's Council last year to establish the Royal Show in the Midlands as an alternative to the system whereby the Show is staged in different parts of the country each year.

Lord Leigh has been a member of Council of the Royal Agricultural Society of England since 1944. He is Senior Steward of the Grand Ring at the Royal Show.



a killer you don't have to handle with care

SEVIN Insecticide—a new kind of pesticide—Powerful Enough to Kill Resistant Insects, Yet Safer to Handle than DDT.

Years of Union Carbide research has developed a new kind of insect killer, SEVIN Insecticide, that is chemically different from any other insecticide now in commercial use. SEVIN is a powerful carbamate and has proved highly effective against fruit and vegetable insects, forest and ornamental pests, animal ticks and lice—*even those insects that have developed resistance to other insecticides.*

SEVIN Insecticide potency lasts longer in the field and fewer sprayings are required to do an effective job. SEVIN appears less toxic to humans and animals than DDT. Field workers can continue operations immediately after a SEVIN spraying.

SEVIN has no objectionable odor and is compatible with most other chemicals so you can combine a complete insect control program in one formulation.

Find out how SEVIN can help you control insect damage and improve the quality of your crops. Write today for detailed information CPT 11 to the Chemicals Department, Union Carbide International Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y., U. S. A., Cable Address: UNICARBIDE, New York.

PHYSICAL PROPERTIES: CHEMICALLY PURE 1-NAPHTHYL N-METHYLCARBAMATE IS CHARACTERIZED BY:

appearance	white, crystalline solid
odor	essentially odorless
melting point	142 deg. C.
vapor pressure	less than 0.005 mm. Hg at 26 deg. C.
density	1.232 at 20/20 deg. C.

UNION CARBIDE
TRADE MARK
Chemicals

NEWS AND NOTES

N.A.A.S. announce retirement of Mr. J. A. McMillan, C.B.E., B.Sc. (Agric.)

Mr. J .A. McMillan, C.B.E., B.Sc. (Agric.), Director of the National Agricultural Advisory Service since August, 1959, will be retiring from the public service in February, 1961.

Mr. McMillan will be succeeded by Mr. W. E. Jones, B.Sc. (Agric.), at present Senior Advisory Officer (Agriculture).

Mr. J. W. Reid, O.B.E., N.D.A., F.A.C., at present Regional Director of the National Agricultural Advisory Service, Yorks. and Lancs. Region, will succeed Mr. W. E. Jones. A further announcement about Mr. Reid's successor at Leeds will be made in due course.

Pyrethrum expert accepts editorship

Dr. T. F. West, D.Sc., Ph.D., F.R.I.C.A., M.I.ChemE., is to be the new editor of *Chemistry and Industry* in succession to the late Mr. W. E. Dick.

Dr. West is well kown to members of the Pesticide Industry as European Operations Executive of the Pyrethrum Board of Kenya but previous to this his work on insecticides had not gone unnoticed.

For some years he served as Chief Chemist to Stafford Allen & Sons Ltd. ; during the second world war he was seconded for special duties to the Office of Scientific Advisors, Ministry of Production and in 1943 visited India in connexion with the use of insecticides in war. At this time he was a member of the Consultative Committee of the Imperial Institute on Insecticide Materials of Vegetable Origin.

In 1947, Dr. West joined the staff of the Ontario Research Foundation as an Assistant Director and towards the end of 1948 he accepted the post of Director of the Development Division, Drug Houses of Australia Ltd. Early in 1958 he became European Operations Executive for the Pyrethrum Board of Kenya.

For many years Dr. West has had a close connection with the Society of Chemical Industry, publishers of *Chemistry and Industry*. He has contributed a number of papers to the Society's and other journals and is also the co-author of three books namely " DDT and the Newer Persistent Insecticides ", "Chemical Control of Insects " and " Synthetic Perfumes ".

One Day Course on Timber Decay

A one-day course concerning the problems caused by the activities of woodboring insects and wood-rotting fungi was held at the Woodworm and Dry Rot Centre, 16 Dover Street, W.1. on 4th October. It was attended by nearly fifty architects, surveyors, estate agents and others interested in problems of timber decay.

During the morning Dr. N. E. Hickin spoke on " The Problem of Woodboring Insects ", W. J. Holmes discussed " The Increase in Woodworm Activity ", and R. K. Farmer explained " How a Timber Fluid Works ". After lunch R. Beeching spoke on " The Problem of Fungal Decay " followed by A. A. Tyrer on " The Treatment of Fungal Decay ", and there was afterwards a lively question forum.

Micron Sprayers for Pakistan

First shipments of Micron concentrate crop spraying machines against the £37,500 order received in June from the Pakistan Government, were made on September 9th and 13th.

The first shipment, to Dacca via Chittagong, consists of 150 shoulder-mounted and four trolley-mounted Micronette machines and these being followed by the shipment to Karachi of 50 shoulder-mounted and 20 trolley-mounted Micronettes. The balance of the order comprises 300 Micronettes, 10 Micron Megs and nine sets of Micronair equipment ; shipment of these will follow shortly.

These various machines, manufactured by Micron Sprayers Ltd., will be used for control of pests in a variety of crops which include rice, jute, sugar cane, cotton, oil seed, mango, citrus fruit and tea.

Continued from page 31

The Unknown Quantity

The Nyasaland administration held a meeting with the villagers to explain the dangers of this decision. For example since the area had been sprayed every year for five years the majority of children under the age of four would not have been subjected to attacks of malaria which if they do not prove fatal confer on the victims a certain degree of immunity lasting until adult life. Consequently failure to carry out spraying this year would mean that these children would be liable to suffer severe if not fatal attacks of malaria. Unfortunately the villagers refused to change their mind.

On the evidence available the reasons for this strange decision are a matter of conjecture but there are two main possibilities.

(a) the villagers were not adequately instructed from the beginning of the scheme into the causes of malaria and its dangers.

(b) political agitation.

Whatever the cause the only way to produce a permanent solution is to educate the people. This does not mean that they should be taught all the technical details but they should be given a fundamental education and above all be trained or encouraged into that flexible state of mind whereby traditions and past experience can be dispassionately weighed against new, often apparently revolutionary ideas to produce a balanced judgement.

Of course this is a long term policy and would take at least two or three generations to produce any significant results. For the present and near future, we require the kind of person who can teach an old dog new tricks.